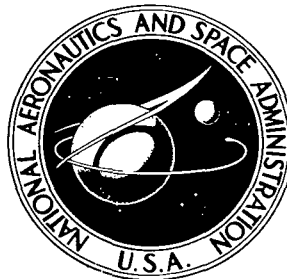


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STRESS EFFECTS OF HIGH NOISE LEVELS ON LOWER BODY NEGATIVE PRESSURE EXPERIMENTS

by R. E. Allen, R. L. Trobaugh, and B. B. Henson

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16. Abstract <p>The purpose of this study was to examine the effects of high noise levels on subjects experiencing lower body negative pressure. Noise has been cited as one form of stress that might impact the physiological data, and this study was designed to investigate further this question.</p> <p>The subjects participating in this study were five male employees at Marshall Space Flight Center, Huntsville, Alabama. Their ages ranged from 24 to 33 years, and all were in good physical condition. Each subject was required to have hearing sensitivity within normal limits and to have had no excessive exposure to noise prior to testing.</p> <p>Each subject was given a complete audiological examination to determine his hearing level prior to testing. Noise levels of varying intensities were introduced through earphones to the subject while he was in the lower body negative pressure device (LBNPD). Physiological data were collected prior to the experiment to establish each subject's baseline response. The noise experiment lasted 30 minutes, and each subject experienced 4 bursts of 100dB pink noise for a duration of 1.5 minutes each. A negative pressure of -40 mmHG was maintained for 12.5 minutes. The physiological parameters measured on each subject were EKG, blood pressure, GSR, respiratory rate, respiratory volume, lower body temperature, and upper body temperature. Ambient conditions in the laboratory were also monitored, and the testing was recorded on a tape recorder for the purpose of recall.</p> <p>The results indicated that 100 dB of noise given at random time intervals throughout the lower body negative pressure test produced no significant recurring effects on heart rate or blood pressure that could be credited to the noise stimulus. The introduction of noise did affect the GSR, indicating that high noise levels do produce some stress on subjects in the LBNPD.</p>					
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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation or Symbol	Definition
LBNPD	lower body negative pressure device
GSR	galvanic skin response
mmHg	millimeters of mercury
min.	minutes
↑	100 decibels of pink noise on
↓	100 decibels of pink noise off
PVC	peripheral vasoconstriction
A, B, C, D, E	subjects — Examples: A_1 — subject A, test 1; A_2 — subject A, test 2; etc.

STRESS EFFECTS OF HIGH NOISE LEVELS ON LOWER BODY NEGATIVE PRESSURE EXPERIMENTS

SUMMARY

This study was undertaken to determine whether high noise levels would impact physiological data being monitored while subjects were experiencing lower body negative pressure. Noise has been cited as one form of stress that might impact the physiological data, and this study was designed to investigate this hypothesis further.

The subjects chosen for participation in this study were five male employees at Marshall Space Flight Center, Huntsville, Alabama. Their ages ranged from 24 to 33 years, and all were in good physical condition. Each subject was required to have hearing sensitivity within normal limits and to have had no excessive exposure to noise prior to testing. Each subject was given complete audiological testing to meet these criteria.

The experiment was carried out with the subject in the Melpar LBNPD. Physiological data were collected prior to the experiment to establish each subject's baseline response. The noise experiment lasted 30 minutes, and a negative pressure of - 40 mmHg was maintained for 12.5 minutes. Four bursts of 100 dB pink noise for a duration of 1.5 minutes each were introduced through earphones to the subject while he was in the LBNPD.

Physiological data were measured continuously throughout the tests. EKG, blood pressure, GSR, respiratory rate and respiratory volume measurements were recorded on a Physiograph. A Strip Chart Oscillograph measured lower body temperature, and upper body temperature. A Leg Pleythsmograph was also used. Ambient conditions in the laboratory were monitored by a Hygro-thermograph, measuring temperature and humidity in the room and in the device. The testing was recorded on a tape recorder for the purposes of recall.

From the results of this noise study, it was found that one 100 dB of noise given at random time intervals throughout the lower body negative pressure test produced no significant recurring effects on heart rate or blood pressure that could be credited to the noise stimulus. The introduction of noise did affect the GSR, indicating that high noise levels do produce some stress on subjects in the LBNPD. Unless sensitive measurements such as the GSR are used, the noise levels, even as high as 100 dB, will not adversely affect the data obtained in the Orbiting Workshop. Test results did indicate that some adaptation to the noise occurred. This would suggest that the subject might initially be startled, thus influencing the test data, but would adapt rapidly with no further change in data occurring. It would be interesting to investigate the increased sensitivity of an individual to random noise preceded by a period of "composed quietness" to determine if his reaction is more or less as compared to this data.

INTRODUCTION

To understand the stress effects of high noise levels on subjects in the lower body negative pressure device, it is first necessary to consider the physical parameters involved. These are the auditory stimulus employed and the receptor.

Noise, the auditory stimulus, is complex sound composed of different wave forms superimposed upon each other. A definition suitable for this experiment would be that noise is an undesired sound producing an adverse reaction in the central nervous system of the receptor; i.e., the subject in an experiment.

The three types of noise most often used in psychoacoustical testing are white, pink, and USASI. In this experiment it was desirable to choose a noise that would most nearly approximate the environmental conditions of a space laboratory. Pink noise was the spectrum chosen to measure the stress effects of noise on the receptor; i.e., the subject. Pink noise is based on octaves of energy that is constant per bandwidth. There is a linear 3 dB rolloff per octave (Fig. 1).

The physical stimulus acts on the receptor, in this study a human being with the mechanism of hearing intact, by setting up activity in the form of nerve impulses that convey the information in coded form to the brain. The ear, the most complex of the sensory organs, has a broad

range of responses. Vibrations can be detected from 12 to 20 000 Hz. The human ear also possesses the ability to distinguish some 300 000 tones of different frequency and/or intensity and to analyze complex sounds into their component parts.

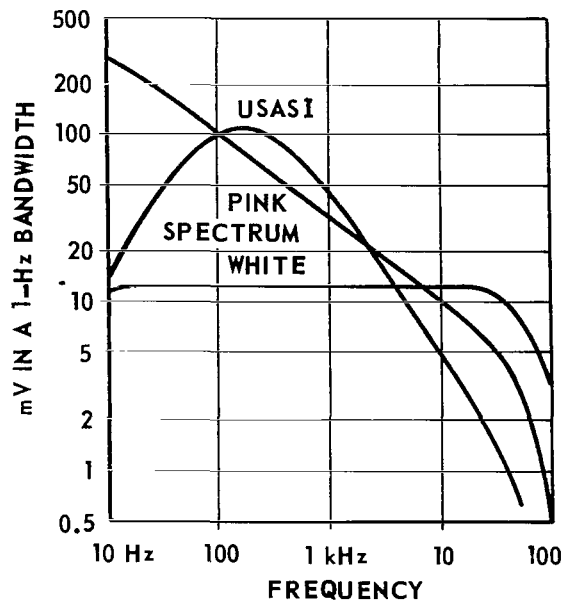


Figure 1. Noise spectra produced by type 1382 generator.

Obviously, such a mechanism is delicate and complex. A simplified description of the anatomy of the ear and the function of hearing will be presented here to provide the reader with a general understanding of the mechanism.

The ear consists of three parts; an external ear, a middle ear, and an inner ear (Fig. 2).

The external ear consists of the auricle and the external auditory canal that leads to the tympanic membrane. The canal is about 25 mm long and is S-shaped. The external ear serves as a conducting channel for the sound, acting in much the same way as a megaphone.

The middle ear, bounded externally by the inner layer of the tympanic membrane, is an air-filled cavity maintained at atmospheric pressure by the periodical opening of the eustachian tube. Within the cavity are three small ossicles; the malleus, the incus, and the stapes. Two muscles are attached to the bones — stapedius to the stapes and the tensor tympani to the handle of the malleus. The stapes is connected to a membrane that seals off the fluid of the inner ear at the oval window. The round window, located below and in front of the oval window, is very small and is covered by a thin membrane. The middle ear has three functions:

1. It transmits energy from the external auditory canal to the fluid contained within the cochlea.

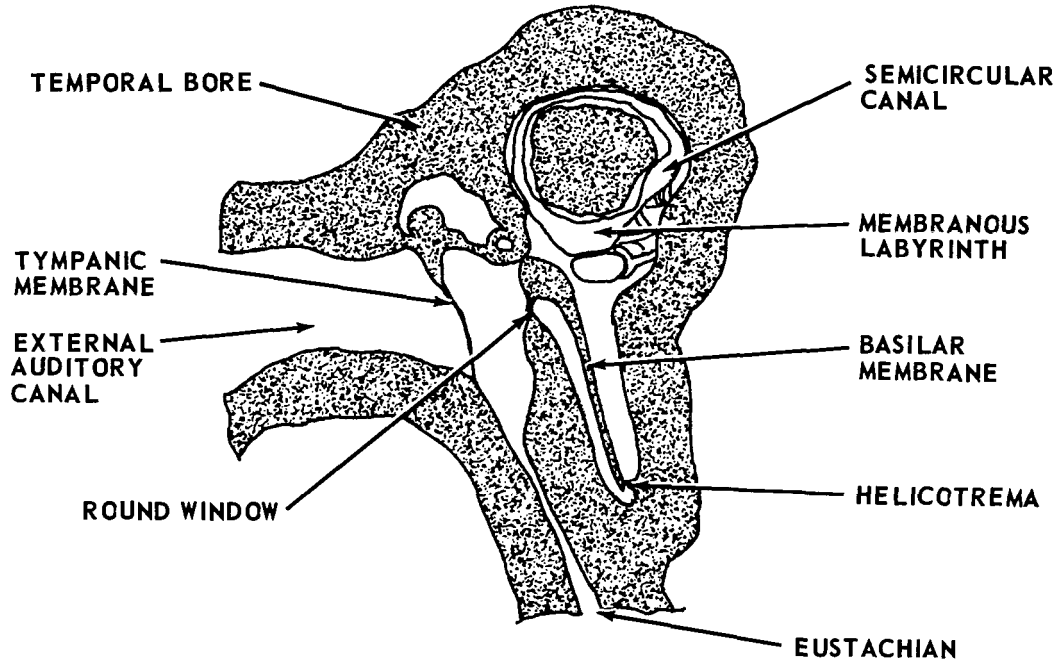


Figure 2a. Schematic drawing of the human ear.

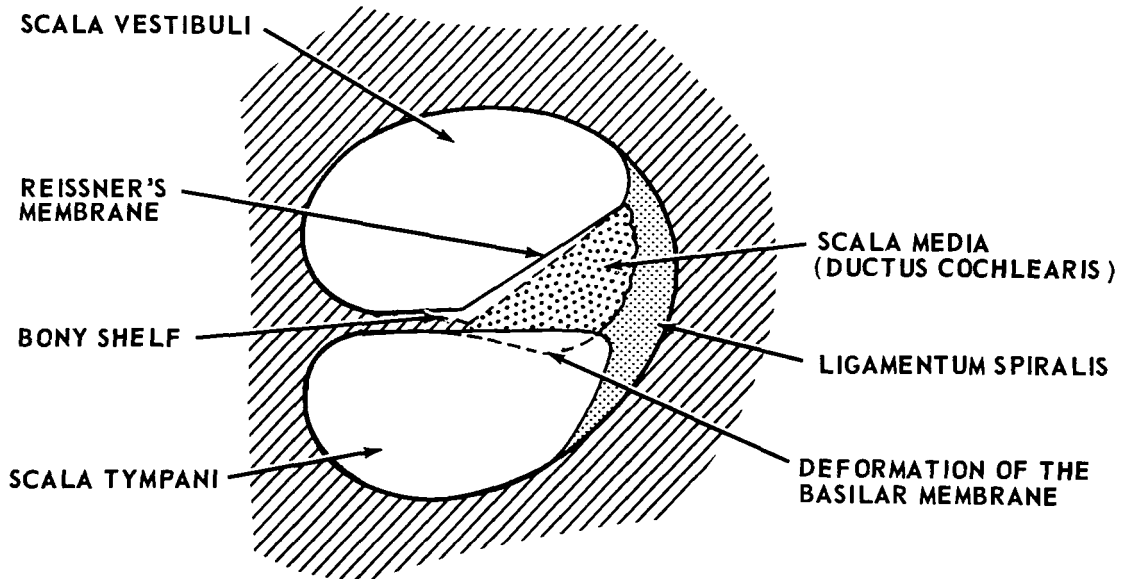


Figure 2b. Schematic cross section of the cochlear channels.

2. It serves as a protective device from intense sounds of low frequency by the reflexive action of the muscles.

3. It equalizes air pressure.

The inner ear, the source of the sense of hearing, is a system of cavities in the bone of the skull containing the mechanism for balance as well as the auditory part of the cochlea. The cochlea is a spiral cavity about 35 mm long and coiled 2 1/2 turns like a snail's shell. The cochlea consists of three canals that are separated by Reissner's and the basilar membrane. The three canals are the scala tympani, scala vestibuli, and the scala media. These canals contain fluid and serve as a hydrodynamic system.

Enclosed in the canals is the end organ of hearing, the organ of Corti. This structure rests on the basilar membrane and consists of a series of projecting hair cells. There are three parallel rows of outer hair cells and one row of inner hair cells. From these hair cells run nerve fibers to the central core of the cochlea. There the fibers form the auditory nerve and pass to the base of the brain where they synapse with other fibers leading to the central hearing mechanism in the cortex.

The vibrations coming from the outside to the middle ear cause an inward movement of the stapes at the oval window. This in turn produces an outward movement at the round window. Reciprocal movement is set up, and the wave-like movements set up the nerve impulses in the organ of Corti.

The moving parts of the ear are seldom at rest. Their normal state is one of motion. High noise levels can set up activity beyond their mechanical limits of tolerability, then physiological changes may occur. Noise affects man at two levels; stress, and physical damage to the auditory mechanism. In this study, we are concerned with the stress effects of noise. G. Lehmann [1] has categorized reactions to noise into two levels, the secondary vegetative reactions and the primary vegetative reactions.

The secondary vegetative reactions occur as a consequence of the conscious perception of noise. As different persons or even the same person under different situations respond differently both quantitatively and qualitatively to the same noise, there is a wide range of reactions. In general, the noise produces a definite feeling of annoyance and irritability.

Often there is an increase in muscle tonus. It has been observed that higher frequency noise is generally more annoying. Intermittent noises also produce more stress.

The second level of reactions is the primary vegetative reactions. These are independent of consciousness and can occur beyond a sound level of 65 dB. A characteristic reaction is the contraction of the blood vessels in the precapillaries, mainly in the skin and mucous membranes. There is usually no increase in blood pressure, and pulse frequency remains constant for the most part. It is observed that cardiac output per minute is reduced, and changes in glandular activity and dilation of the pupil of the eye may occur.

Intensity of the reactions depends on sound level, the bandwidth of the noise, and the mean frequency. Lehmann [1] also observed that whether or not the individual was accustomed to the particular type of noise made no difference.

Those concerned with the medical problems encountered by the astronaut are becoming increasingly aware of the effects of noise in the spacecraft. In considering long space flights, it is necessary to be able to forecast man's ability to carry out work in the cabin. More investigations are needed to determine the consequences of high intensity noises on the astronaut.

There are two main stages of noise in the cabins of the spacecraft. The first stage is the short but intensive sounds occurring during the period of active propulsion. The second stage of noise is the prolonged and continuous sounds of medium and low intensity when the craft is in orbital movement. The main source of noise is the assembly of life-supporting systems. These function continuously and create a permanent acoustic background in the cabin. Occasionally other environmental noises are introduced. It is the concern of this study whether or not unexpected bursts of noise in the cabin would produce stress effects upon the astronaut while he is in the lower body negative pressure device. A review of the literature does suggest high noise levels might affect the subject's performance.

Lehmann [2] found in his research that noise produces a contraction of the precapillary blood vessels over the vegetative nervous system. This reaction occurs at noises of 65 dB and increases with the increase in noise level. He found that the vasoconstriction holds on during the entire duration of the noise and is dependent upon the spectral latitude of the noise.

Gerd Jansen [3] performed an experiment studying the influence of noise on manual work. The influence of wide-band noise (30 to 20 000 Hz at 95 dB) and three-band noise (medium frequency of 3200 Hz) was determined in a six-experiment series on medium heavy work on a bicycle ergometer. It was discovered that the wide-band noises exerted a significant influence on the reduction of the blood circulation, while the three-band noises had no influence on blood circulation.

Oppliger and Grandjean [4] found during plethysmographic investigations that a decrease in volume occurs under the influence of noise. They felt this was a result of the noise-conditioned decrease of the blood supply to the periphery. Lehmann and Tamm [5] reported that they observed a decrease in cardiac output in addition to the peripheral resistance increase in the majority of their cases.

In 1942 Silink and Sedlacek [6] determined that the influence of noise produced a minimal lowering of the skin temperature. They were assuming that the noise had a vasoconstricting effect on the periphery.

More recent experiments emphasize that the extent of the vegetative reactions depends on the intensity and bandwidth of the noise and is also modified by other environmental influences, such as physical labor and heat [7].

Krylov [8] performed an experiment in which he studied the effects of certain space flight factors on the auditory reactions in man. Individuals were exposed to continuous high frequency (800 to 2000 Hz) noise of 75 dB intensity for periods from 8 hours to 30 days. No physiological indices, such as respiratory rate, blood pressure, and electrocardiographic elements, changed until the subjects had been exposed for 10 days. At the end of this period of exposure, auditory thresholds were raised by 20 to 25 dB. The subjects were troubled by headaches and noises in their ears. Cardio-vascular reaction to a standard physical load revealed some reduction of vascular tone, and physiological examination of the subjects revealed signs of fatigue. It was concluded that exposure to 74 to 76 dB of noise continuously over a period of 10 days has a marked general effect on man.

Research indicates that high noise levels do affect man and his ability to carry out tasks. The purpose of this study is to examine the effects of high noise levels on subjects experiencing lower body negative pressure. Noise has been cited as one form of stress that might impact the physiological data, and this study is designed to investigate further this question.

PROCEDURES

This study was undertaken to determine whether high noise levels impact physiological data being monitored while subjects are experiencing lower body negative pressure. Each subject was given a complete audiological examination to determine his hearing level prior to testing. Noise levels of varying intensities were introduced through earphones to the subject while he was in the lower body negative pressure device. Physiological data were collected.

Subjects

The subjects were employees at Marshall Space Flight Center in Huntsville, Alabama. Five male personnel were chosen to participate in the study. Their ages ranged from 24 to 33 years, and all were in good physical condition.

The following criteria were required for the subjects:

1. Each subject was required to have hearing sensitivity within normal limits, as determined by complete audiological testing.
2. Each subject was required to have had no excessive exposure to noise prior to the testing.

All subjects were tested in the morning with the following conditions being met:

1. No subject varied more than ± 3 pounds in weight during the test period.
2. The last meal was more than 3 hours before the test.
3. No exercise was done at least 4 hours before the test.
4. No drugs were being taken at the time of the test.
5. No subject had suffered any illness one week before the test.

Each subject was tested two times and one was tested three times.

Audiological Equipment

Each subject was given complete audiological tests at the Rehabilitation Center in Huntsville, Alabama. Hearing acuity was assessed using a Beltone Audiometer (Model 15-C), calibrated according to 1964 ISO standards. The testing was performed in a soundproof suite.

The acoustic testing of the subjects while experiencing lower body pressure was done in the Physiological Laboratory at Marshall Space Flight Center, Huntsville, Alabama. The following equipment was used: Random Noise Generator, Electronic Voltmeter, Headset, Sound Level Meter, and Sound-Survey Meter (Fig. 3).

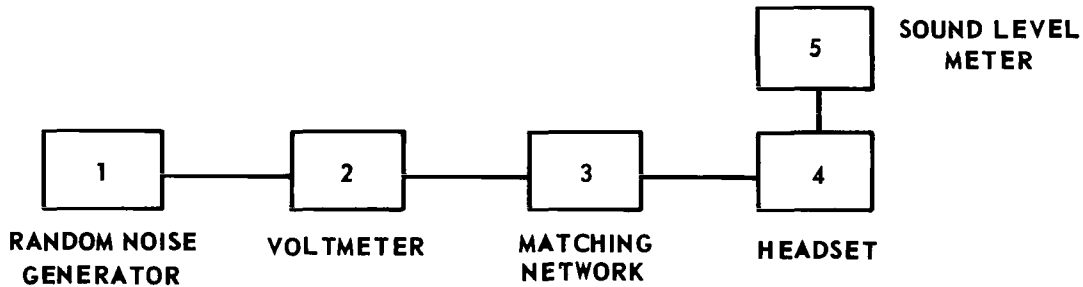


Figure 3. Audiological setup.

The pink noise was generated by a Random Noise Generator (Model 1382, Type 1390-B) which has a frequency range of 20 Hz to 50 kHz. It was manufactured by General Radio Company of Concord, Massachusetts. An Electronic Voltmeter (Model 400 H) was used to measure the electrical signals to correlate decibel levels. The subject wore an MSA Noisefoe Mark II Headset that was carefully calibrated to determine its output power. The noise in the laboratory was measured by a Sound-Survey Meter (Type 15555-A, Serial No. 3716) and a Sound-Level Meter (Type 1551-A, Serial No. 2709). The output of the Random Noise Generator was monitored constantly during testing.

Calibration of the headphones was accomplished by placing each individual headphone of the headset and the microphone in a holding fixture fabricated to the dimensions of these specific instruments. Electrical power at audio frequencies was then applied to the headphones in discrete

steps, and the acoustical power levels were noted. For convenience in use, a calibration chart of millivolts versus sound power level in decibels was developed. This, then, made selection of any desired sound power level immediately possible by merely reading the millivolt input to the headphones. Calibrations were performed for discrete audio frequencies, pink noise, white noise, and USASI noise.

The **items** of equipment used in the calibrations and in actual testing procedures were under valid Standards Laboratory Certification. The system as used consisted of an oscillator, a voltmeter, and headphones with various connecting leads. The system was calibrated exactly as used to minimize possible errors. A completely independent set of equipment and calibration techniques was also utilized, and performances of the two systems were compared. All comparisons of the two independent systems were within 2.0 dB at the 100 dB level. Repeatability of the settings for the 100 dB sound power level was within a 1.0 dB reading on a particular system. There was no discriminable difference in the performance of the left earphone and the right earphone of the headset (Fig. 4). Manufacturers of equipment used in the calibrations and in actual testing procedures are as follow (Figs. 5 and 6):

Oscillator — General Radio 1382

Voltmeter — Hewlett Packard 400 H

Headphones — Wilson

Calibration Microphone and System — Bruel & Kjaer

Physiological Equipment

The experiment was carried out with the subject in the Melpar LBNPD. During testing, the device was constantly monitored visually, and records were made on the Sanborn Dual Channel Recorder. EKG, blood pressure, GSR, respiratory rate, and respiratory volume measurements were recorded on a Physiograph (Type DMP-4A). A Strip Chart Oscillograph manufactured by Brush Instruments measured lower body temperature and upper body temperature. Also used was a Leg Pleythsmograph (Model 270) manufactured by Parks Electronic Laboratory. Ambient conditions in the laboratory were monitored by a Hygro-thermograph (Model 594). It measured temperature and humidity in the room and in the device. The testing was recorded on a tape recorder for purposes of recall.

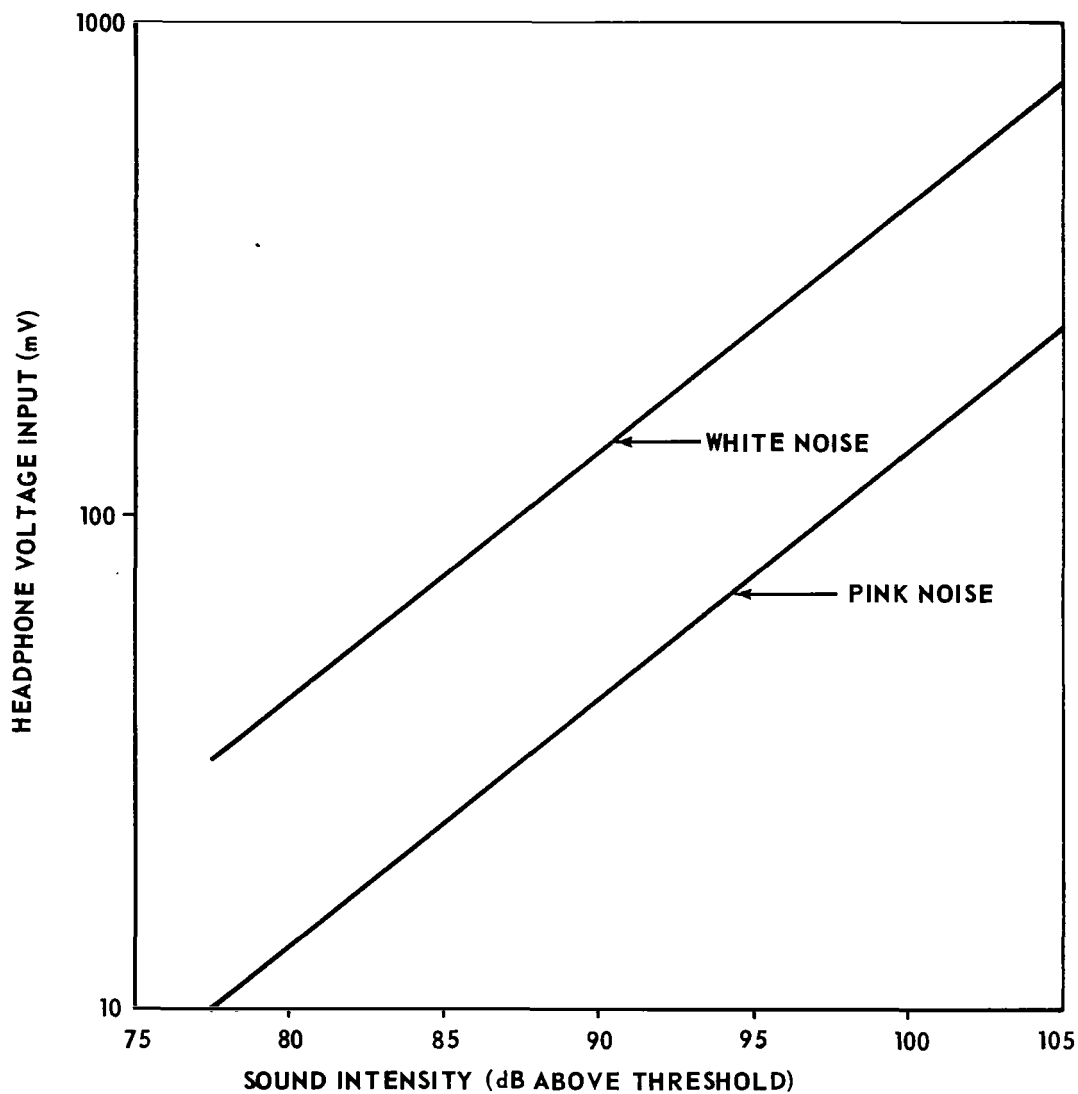


Figure 4. Wilson headphone calibration.

Test Sequence and Procedure

Each subject was given complete audiological tests at the Rehabilitation Center prior to testing. The total time required was 1 hour. A case history was obtained on each subject (example in Appendix). Special emphasis was placed on the subject's history of ear infections and his exposure to loud sounds.

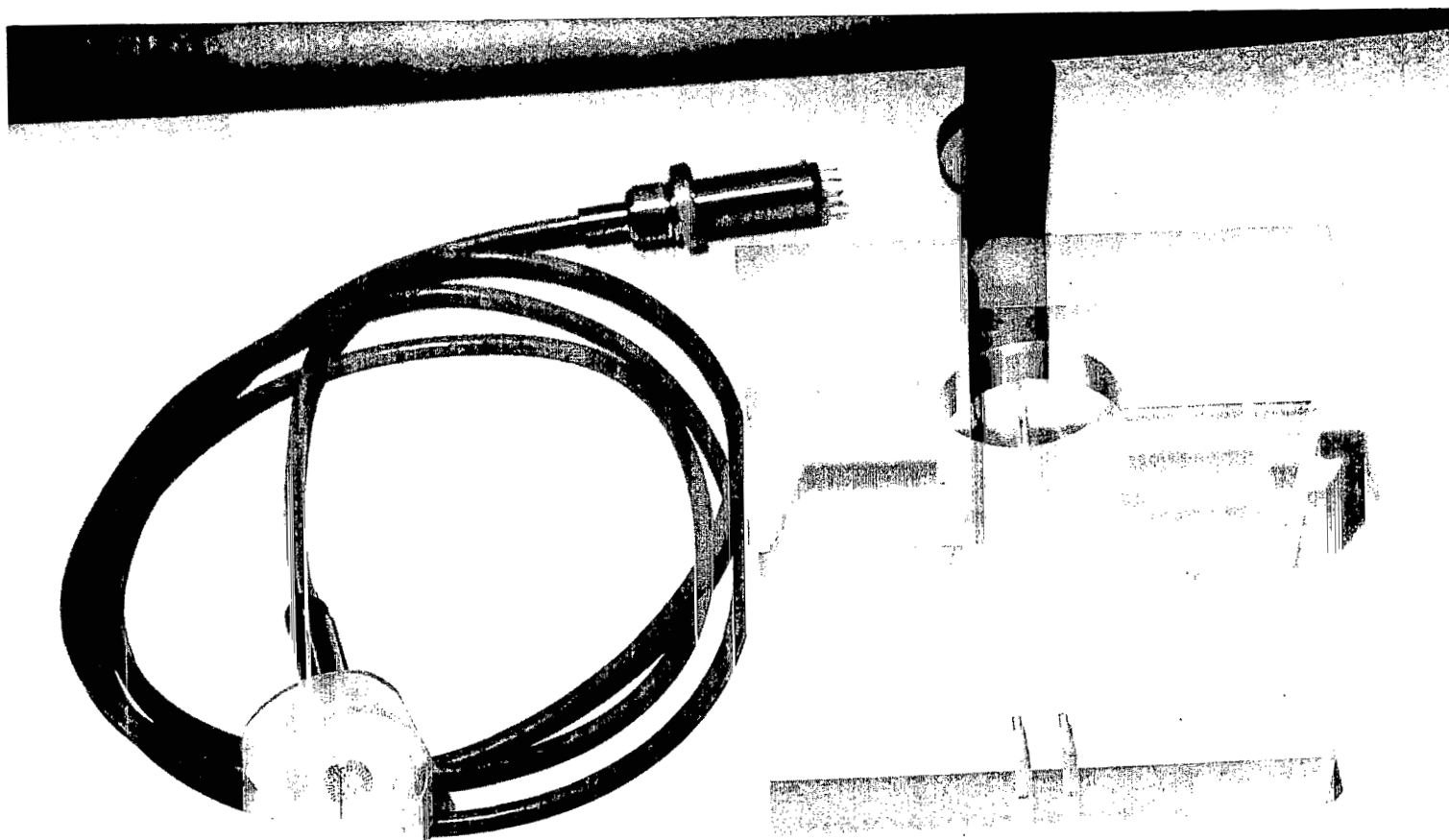


Figure 5. Headphone calibration fixture and microphone.

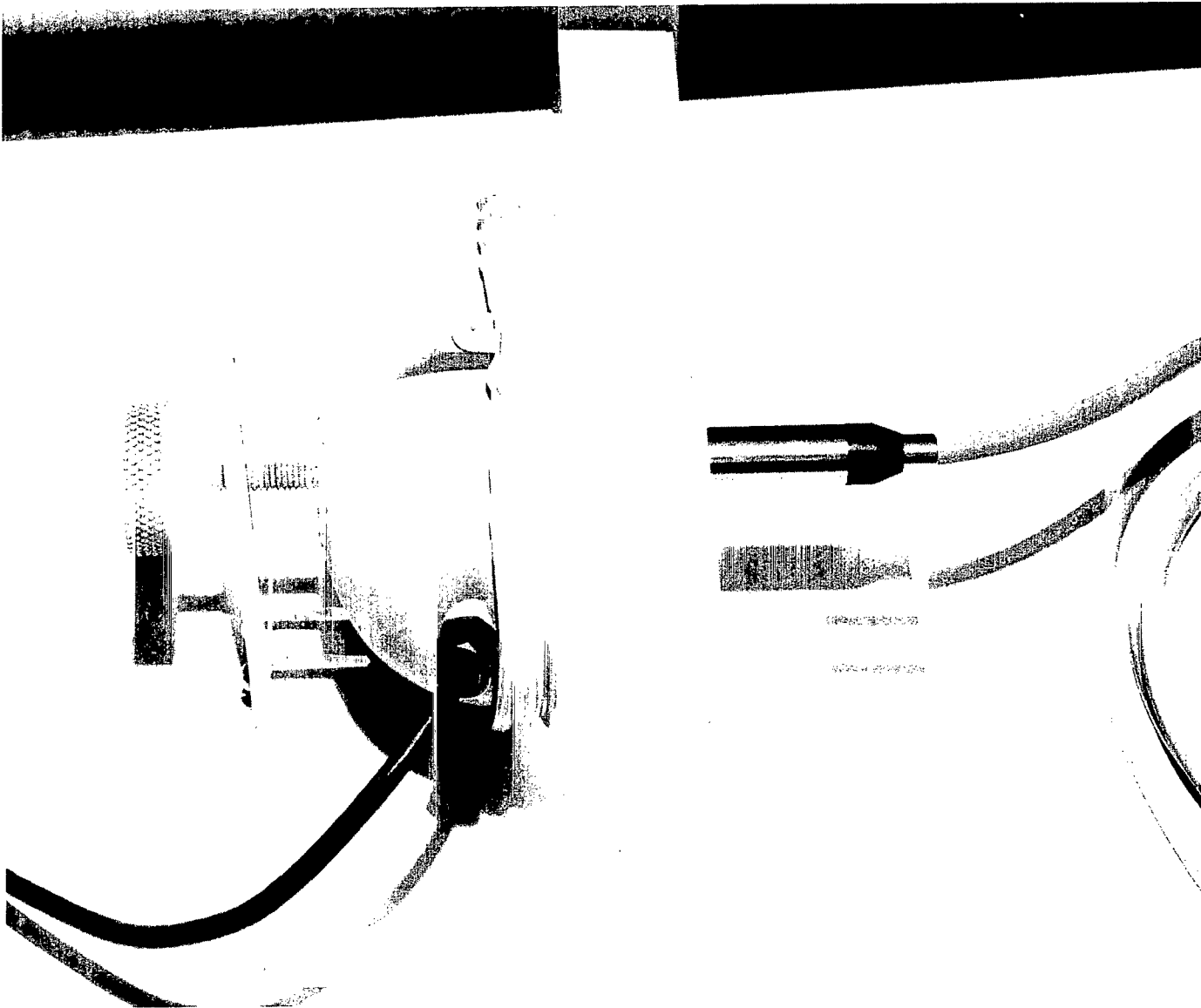


Figure 6. Headphone and calibration microphone in place on the calibration fixture.

Hearing acuity was assessed utilizing pure tones and speech audiometric techniques. The subject was first tested by air conduction commencing with the right ear. The frequencies tested were 1000, 2000, 4000, 8000, 500, 250, and 125 Hz. A descending psychophysical method was used to obtain the thresholds. Bone conduction thresholds were then assessed by the same procedure; testing frequencies were 1000, 2000, 4000, 500, and 250 Hz.

Speech audiometric techniques were then assessed. Speech reception thresholds were obtained with live voice utilizing spondee words. Speech sound discrimination was assessed in a like manner using Harvard's phonetically balanced word lists.

Each subject then reported to the Physiological Laboratory at Marshall Space Flight Center for baseline testing in the Melpar LBNPD. Physiological data were measured and recorded on each subject to establish their baseline response.

After the baseline data were obtained, each subject was ready to proceed with the noise experiments. Each subject was briefed on the general operational procedure. No subject expressed anxiety or fear of the test. The subjects were fitted with the custom earphones to assure no noise filtered from the environment to the subject. Minimum noise was maintained in the laboratory during the test.

The noise experiment was administered as follows:

<u>Time (min.)</u>	<u>Pressure (mmHg)</u>	<u>Pink Noise (dB)</u>
0 — 4	0	0
4 — 5.5	0	100
5.5 — 10	0	0
10 — 13	-40	0
13 — 14.5	-40	100
14.5 — 19.5	-40	0
19.5 — 21	-40	100
21 — 22.5	-40	0
22.5 — 27.5	0	0
27.5 — 29	0	100
29 — 30	0	0

The total time for the experiment was 30 minutes. The subject experienced four bursts of 100 dB pink noise for a duration of 1.5 minutes each. A negative pressure of -40 mmHg was maintained for 12.5 minutes. Each subject was requested to write an assessment of the experiment after he had finished the test.

RESULTS

Upon completion of the noise experiments, the following questions were used as criteria for evaluating the noise data:

1. Did the noise affect the subject's blood pressure or heart rate?
2. Was the response different for repeated exposure to noise?
3. Was the first experimental response different from the second?
4. Did negative pressure significantly alter the response to noise?
5. Can the individual's comments help explain the results?
6. Can the individual's history help explain the results?

To simplify the discussion of the results each subject was assigned a capital letter. (See the List of Abbreviations and Symbols for definitions of abbreviations and symbols used on the data sheets.)

In reviewing the test data for subject A (Figs. 7 and 8), it is apparent that the blood pressure and heart rate varied more in response to negative pressure than to the introduction or cessation of the noise stimuli. The blood pressure remained essentially unchanged in subject A. In both tests, the heart rate indicates the standard recovery profile at the release of negative pressure. It should be noted that even with the increased stress through the negative pressure, no significant response can be detected from the noise given during the negative pressure. The respiratory rate also remains basically unchanged throughout the experiment, a phenomenon observed consistently in other similar noise. The first response has a significantly longer duration than any subsequent response. It might be noted, however, that the response to noise after the subject had experienced lower

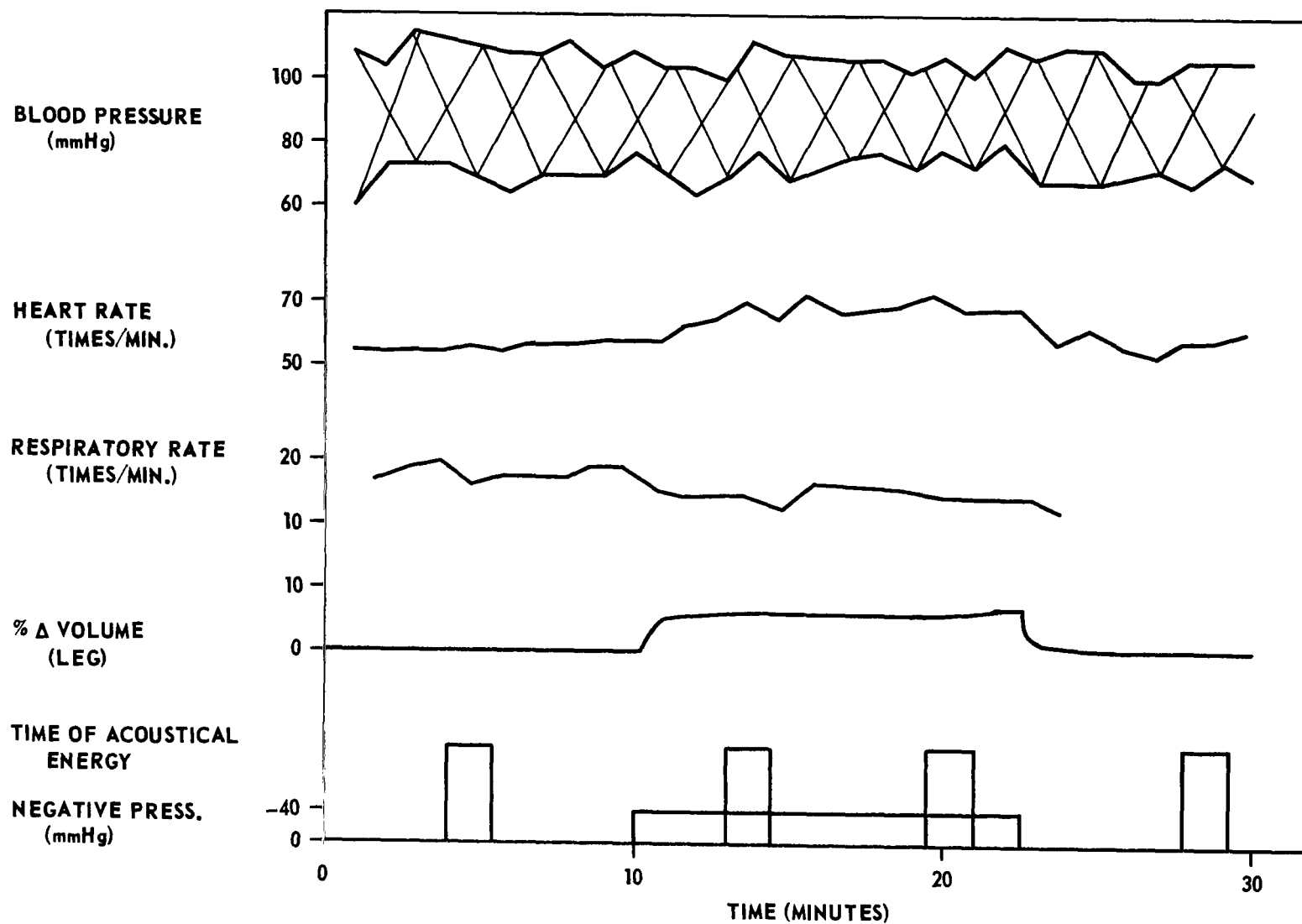


Figure 7. Test data — experiment no. 30, subject A₁.

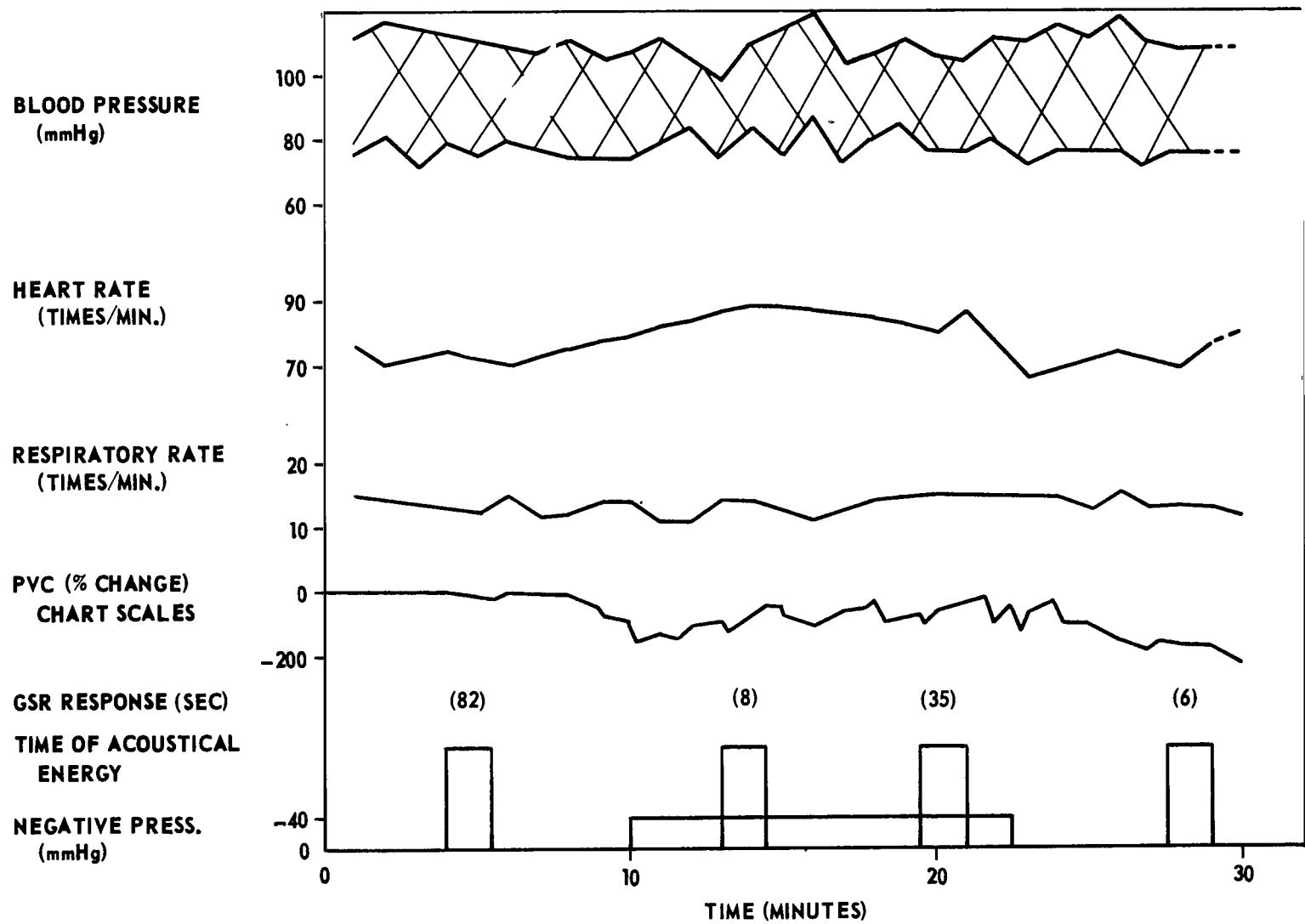


Figure 8. Test data — experiment no. 36, subject A₂.

pressure for 10 minutes was of a longer duration than his response at the beginning of the lower pressure or after its cessation. In the question period immediately after the test, the subject substantiated this phenomenon of adaptation. He stated that the noise is initially frightening, but adaptation occurs quickly. It is interesting to note that a response was recorded with the introduction of noise; however, at no time was there a complementary response in the blood pressure or heart rate.

In this, and all subsequent results, the PVC varies at random during the test. There are some indications of increased PVC, but these findings are preliminary and should be pursued in later tests.

In those tests involving subject B (Figs. 9, 10, and 11), the trends set by subject A are continued. The blood pressure and heart rate did not respond to the addition of noise. In tests B_1 and B_2 there does appear to be some signs of transient tachycardia to the second introduction of noise; however, this is not borne out in previous or subsequent introduction of noise nor in B_3 at all. Adaptation to the noise is not seen in this series of tests. The GSR data show a varied response to noise. In B_3 no difference is seen in the response to noise at the beginning or near the end of the negative pressure, but it is important to note that this subject had very little response to the negative pressure at all. His past history could help explain these results. He participates in many areas of routine stress and excitement. He is a private pilot, drives 20 000 miles per year, and rarely becomes excited. This subject has been tested several times in the LBNPD, and those data are typical of this subject. The subject stated that "the introduction of noise is startling but not annoying." He also reported that he adapted quickly to the stimuli.

In reviewing the test data of C_1 and C_2 (Figs. 12 and 13), there again appears to be no definite change in blood pressure or heart rate because of the noise stress. The GSR data from C_1 is indicative of some adaptation to the noise. In the second test, C_2 , the subject is much more relaxed, and no response on the second test is as great as the lowest response on the first test. It was stated by the subject that the noise was "less unpleasant" during the second test. The heart rate increase in C_2 seems to be more related to the negative pressure than to the noise introduction. Adaptation was not as obvious on the second test as on the first.

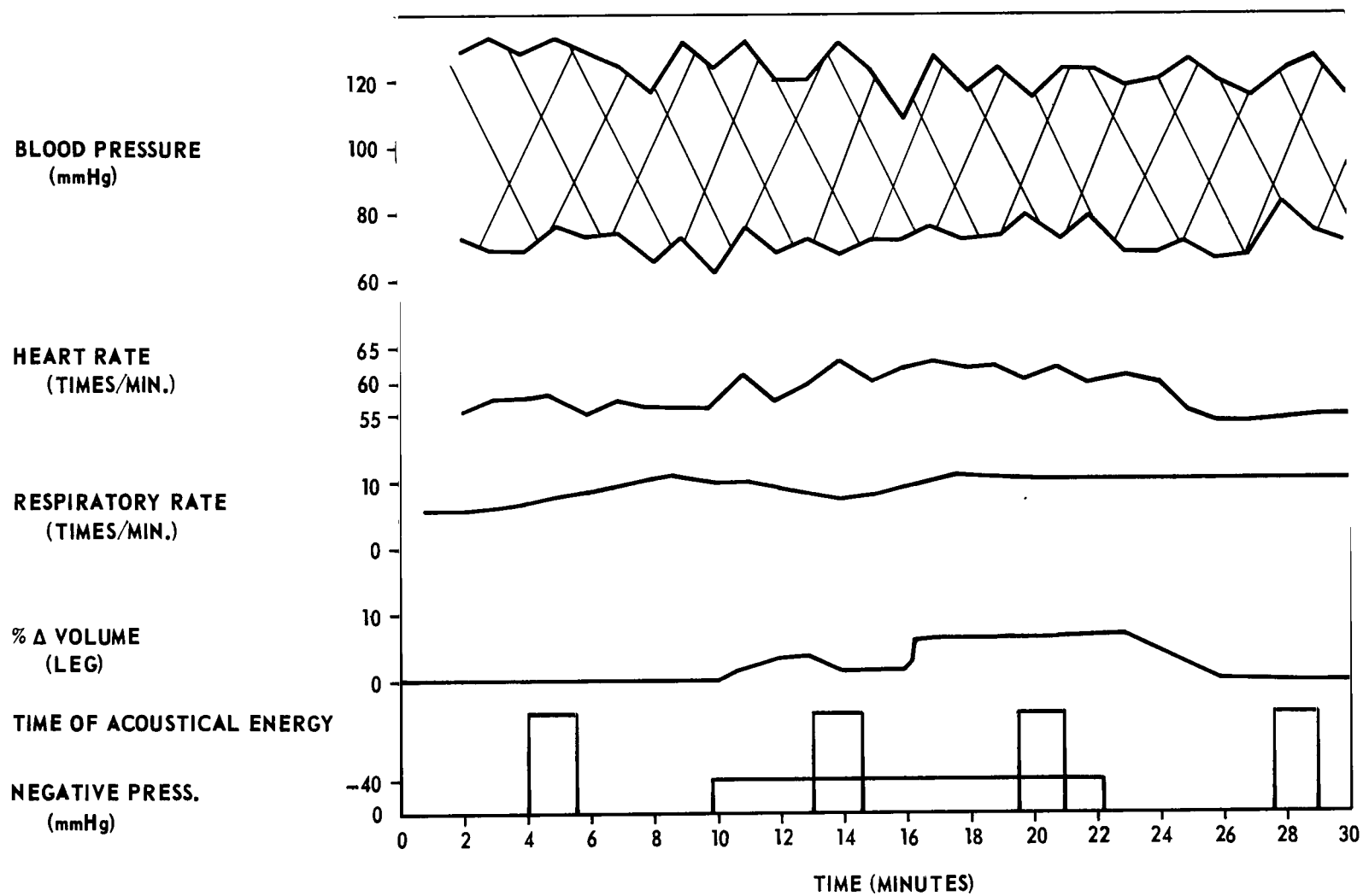


Figure 9. Test data — experiment no. 31, subject B₁.

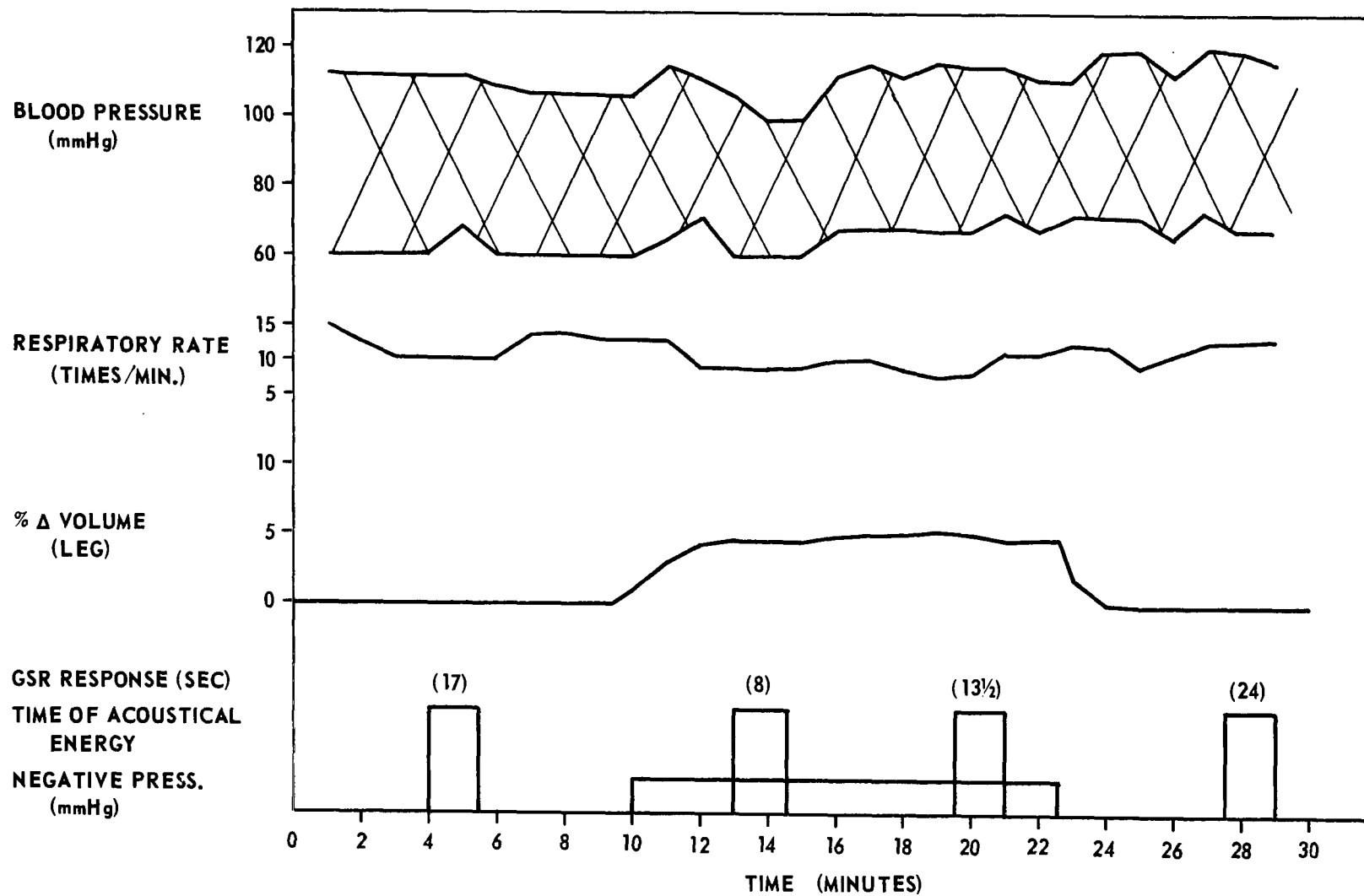


Figure 10. Test data — experiment no. 33, subject B₂.

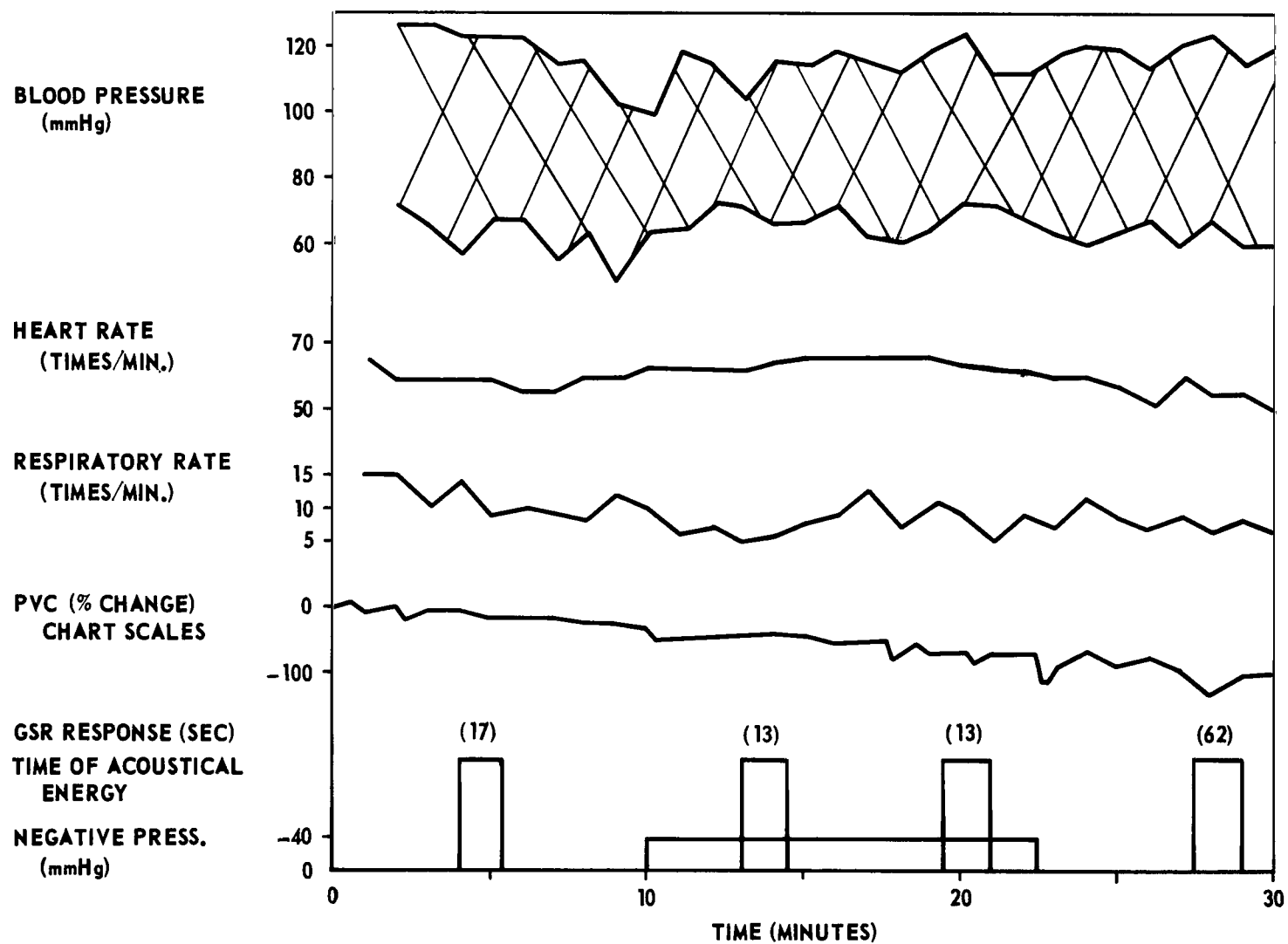


Figure 11. Test data — experiment no. 38, subject B₃.

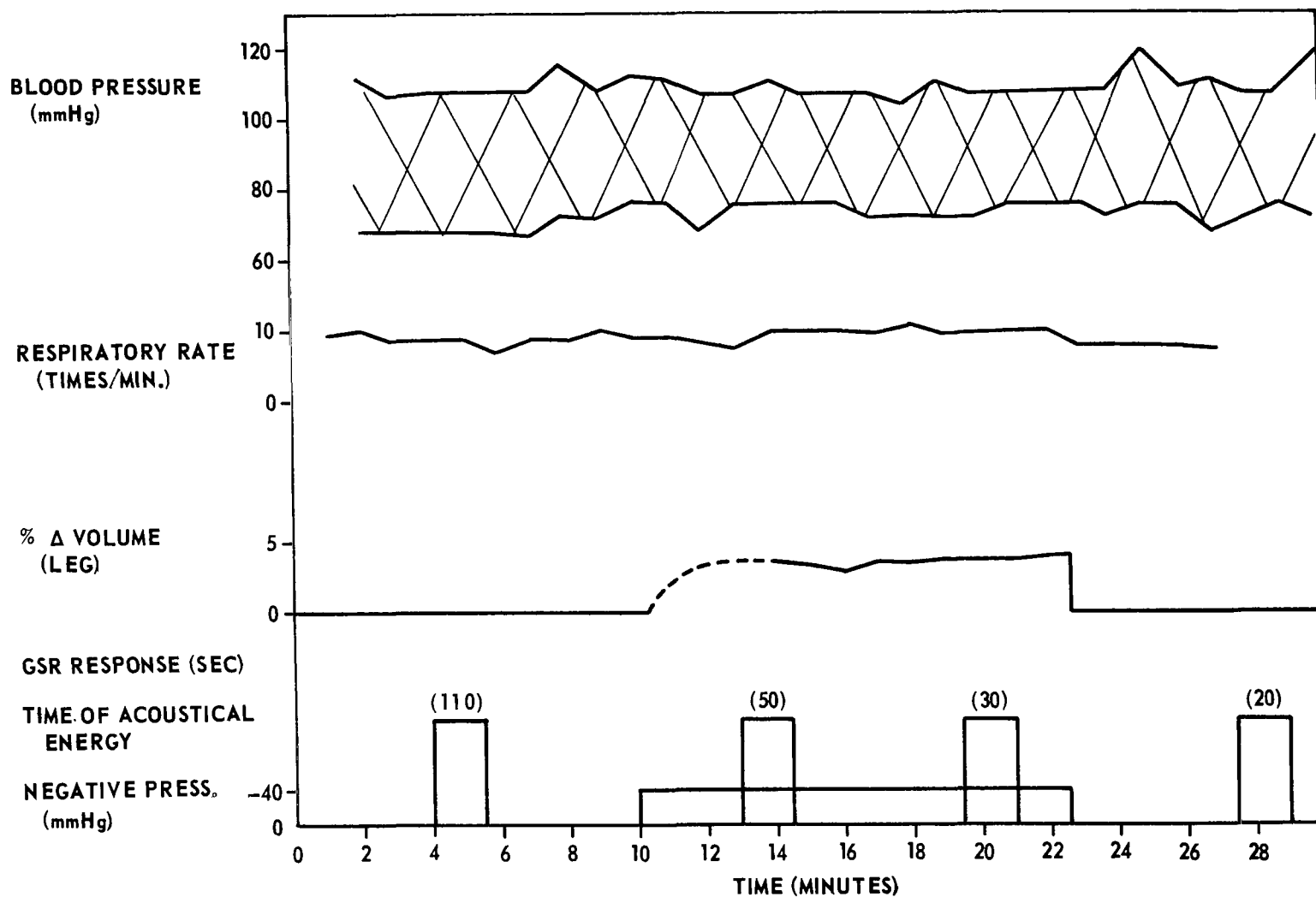


Figure 12. Test data — experiment no. 32, subject C_1 .

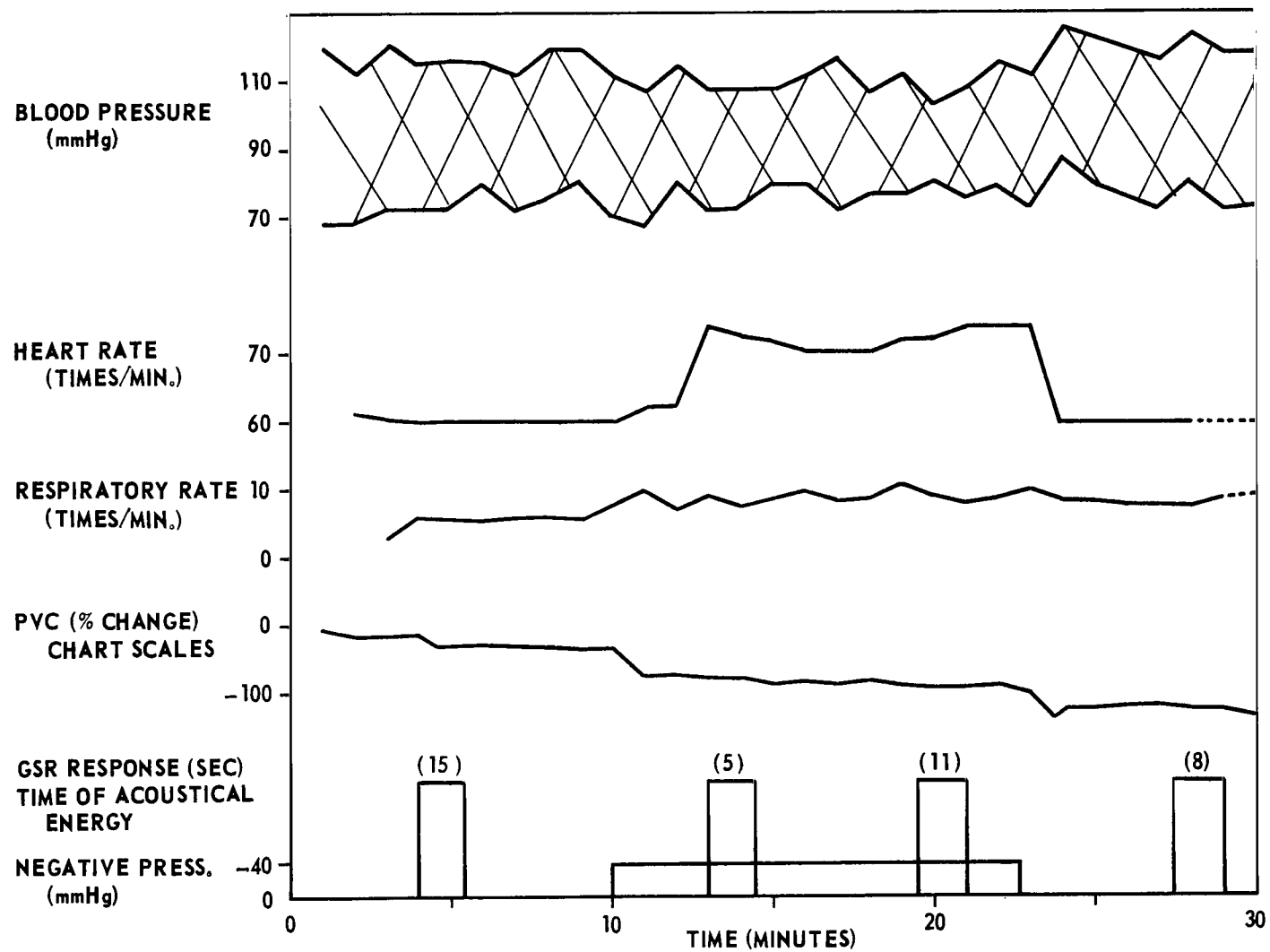


Figure 13. Test data — experiment no. 35, subject C₂.

The heart rate in D_1 and D_2 (Figs. 14 and 15) increased significantly after the induction of negative pressure and decreased, as expected, when the ambient pressure was restored. No similar correlation was found between the introduction of noise and the change in heart rate. The respiratory rate varied a great deal during D_2 but remained consistent throughout D_1 . The subject did express a feeling of annoyance during the test, and the GSR data does not substantiate that the subject reacted strongly to the noise stimulation. It was in the subject's own statement that he said, "I found the noise always startling." Although the introduction of noise did affect the subject's GSR responses, the negative pressure exerted a greater change in his heart rate than did the noise.

Although two tests were administered to E (Figs. 16 and 17), the first one cannot be evaluated in the noise study because the subject's systolic pressure dropped steeply and the ambient pressure had to be restored immediately. The subject's statements after the test reveal that he did not receive an adequate night's rest. Since the test was conducted early in the morning, the lack of rest can be cited as a possible cause of his intolerance to the negative pressure. This subject has participated in other LBNPD tests without problems. The level of excitement in E_1 can be seen in the GSR results as well. This is especially important when comparing his responses on E_2 . As expected, his level of response was much higher during E_1 than E_2 . During E_2 there is a significant increase in heart rate at the onset of the negative pressure and a subsequent reduction when ambient pressure is restored. As in other tests, the significant increase in heart rate is correlated to the negative pressure rather than to the noise. The subject did respond on the GSR when noise was introduced during E_2 . No adaptation to the noise is apparent from the data since his responses varied considerably.

DISCUSSION AND CONCLUSIONS

At the onset of these experiments the purpose was to examine the effects of high noise levels on subjects experiencing lower body negative pressure. It had been stated that no useful data concerning heart rate and blood pressure could be collected if noise was introduced randomly during the test. This would drastically compromise data received from M092 (A Cardiovascular Study: Lower Body Negative Pressure Experiment) from the Orbiting Workshop to be launched in 1972. There was a concern that

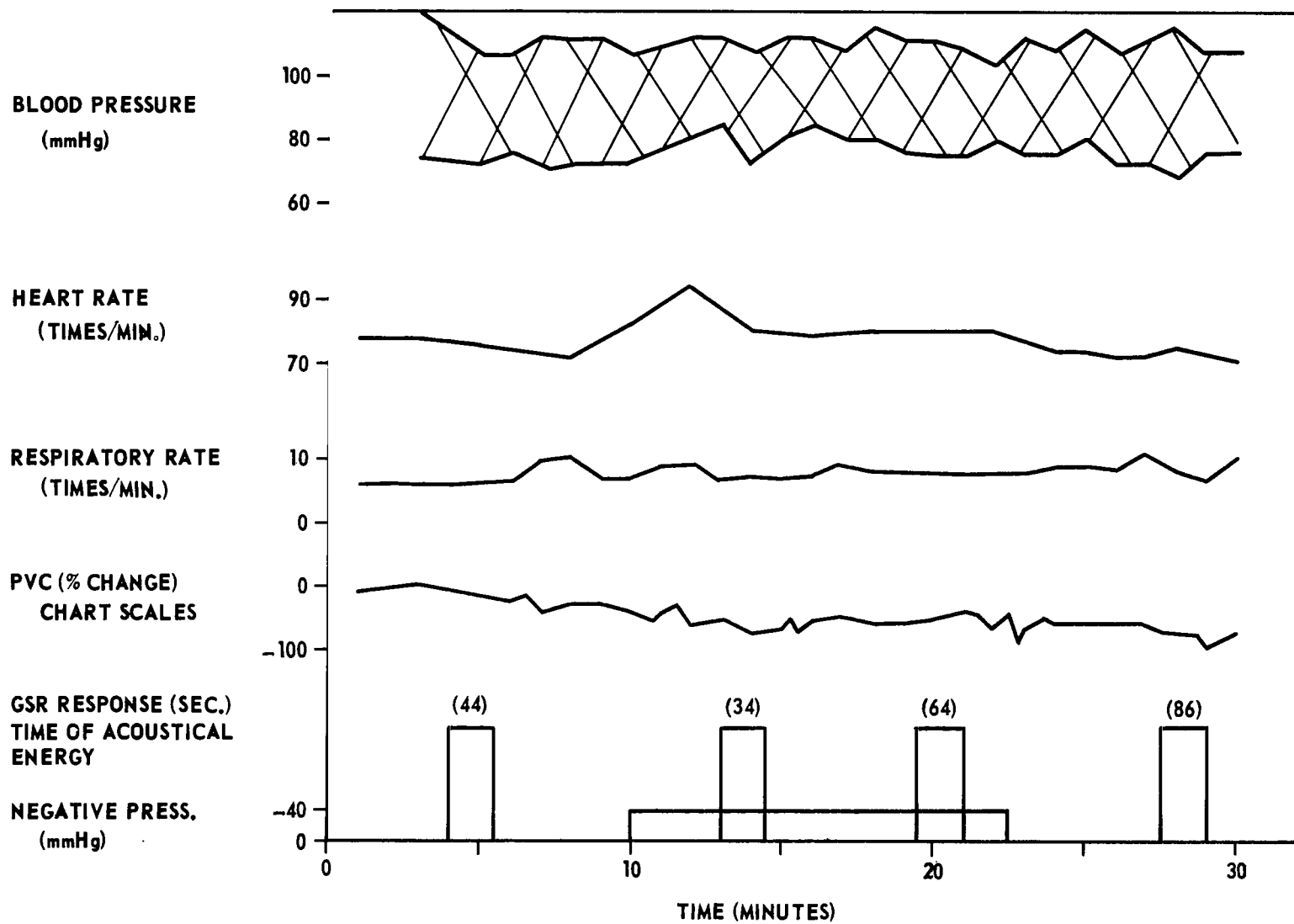


Figure 14. Test data — experiment no. 34, subject D₁.

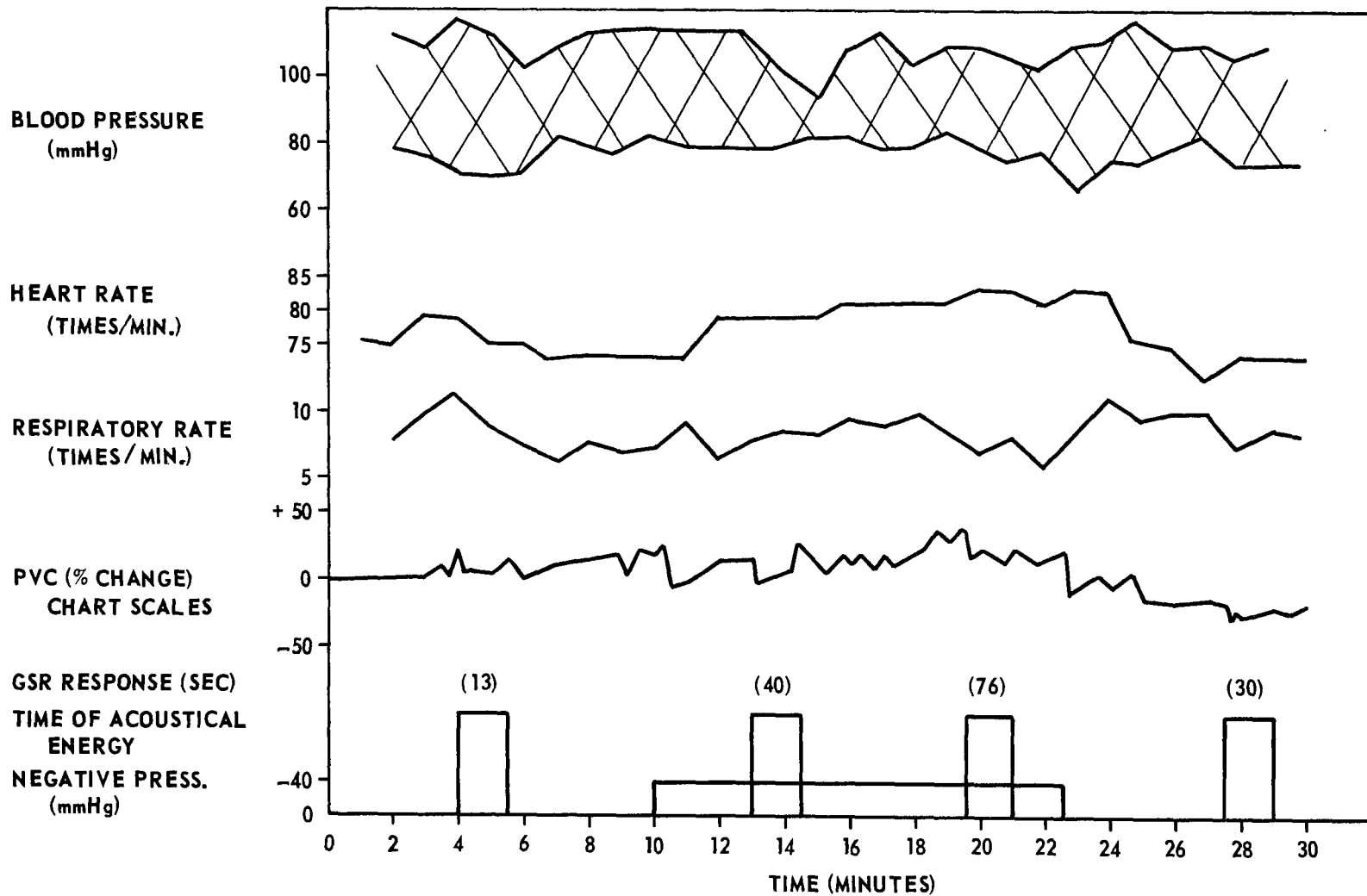


Figure 15. Test data — experiment no. 37, subject D₂.

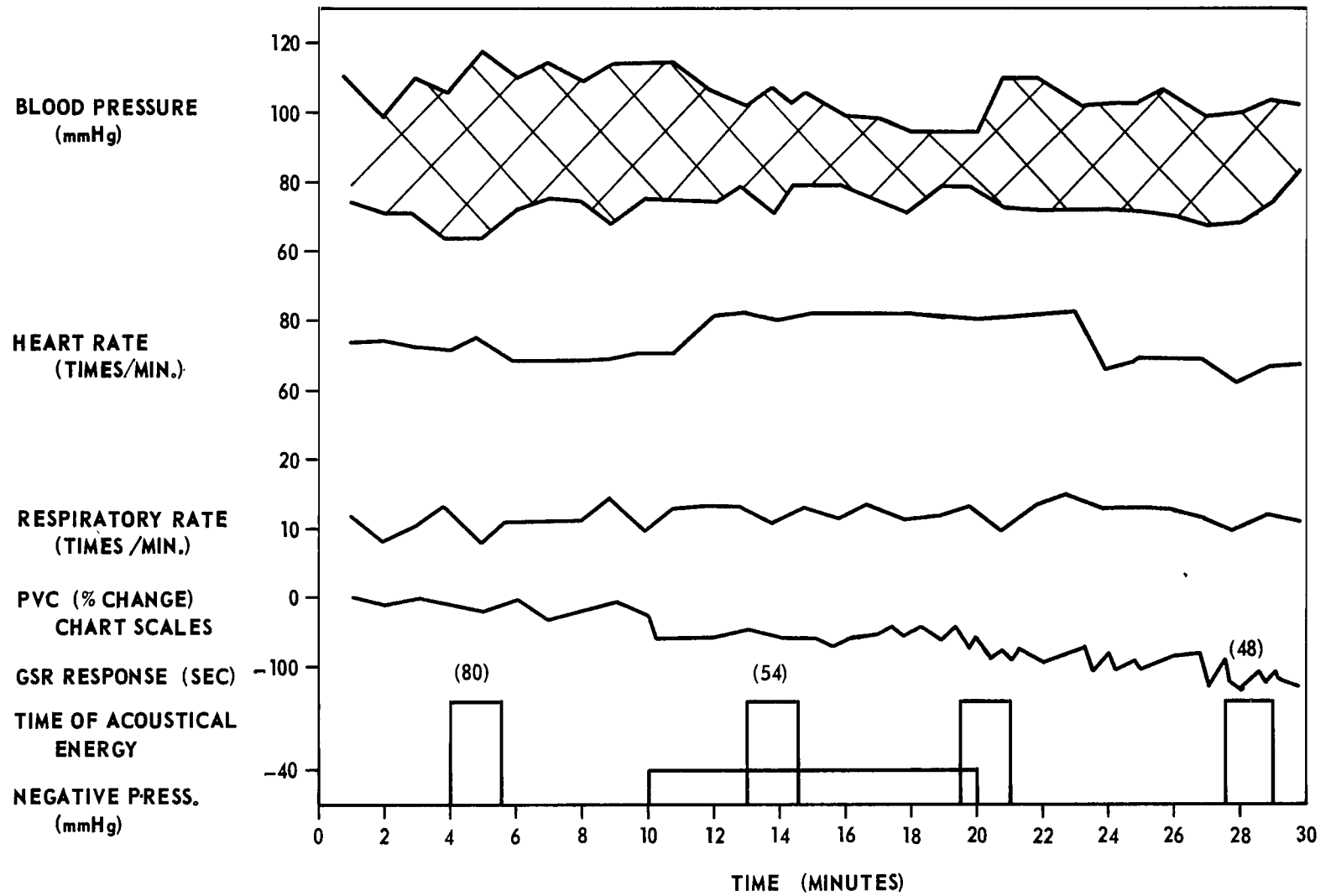


Figure 16. Test data — experiment no. 39, subject E₁.

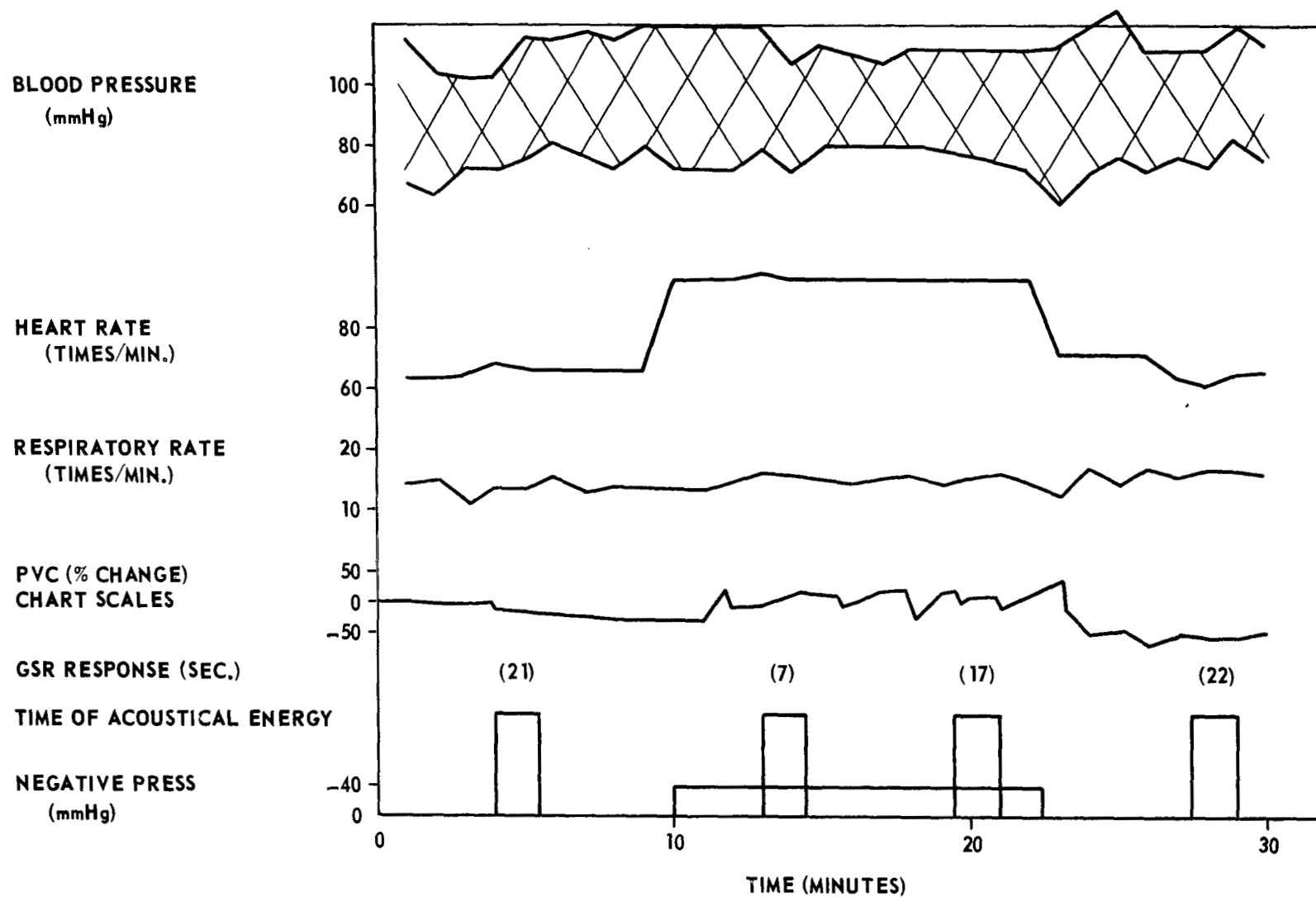


Figure 17. Test data — experiment no. 40, subject E₂.

blowers associated with the environmental control system or other units of equipment might start while the M092 was in progress. For this reason and because of relatively unknown effects of random noise, it was considered critical that the environmental noise be reduced to a minimum during the M092 experiment.

From the results of this noise study, however, it was found that 100 dB of noise introduced at random time intervals throughout the LBNP test produced no significant recurring effects on heart rate or blood pressure that could be credited to the noise stimulus. (These two parameters are emphasized because they will be the ones recorded during the M092 experiment.) The introduction of noise did affect the GSR, indicating that high noise levels do produce some stress on subjects in the LBNPD. Unless sensitive measurements such as the GSR are used, the noise levels, even as high as 100 dB, will not adversely affect the data obtained in the Orbiting Workshop. Test results indicated that some adaptation to the noise did occur. This would suggest that the subject might initially be startled, thus influencing the test data, but would adapt rapidly with no further change in data occurring.

Summary of Major Conclusions

1. No significant repeatable response was recorded in the blood pressure or heart rate because of 100 dB of pink noise being introduced at random periods for 1.5 minute durations.
2. A startle response was recorded in the GSR from subjects given 100 dB of pink noise for the above cited durations. The level of this response varied between individuals and varied for the same individual on the first and second tests.
3. The duration of stress resulting from introduction of noise had no consistent relationship to the duration of lower body negative pressure.
4. The response to 100 dB of pink noise had no demonstrable increase or decrease when superimposed over a lower body negative pressure of -40 mmHg for 12.5 minutes.

It is the recommendation, therefore, that the concern for noise levels up to 100 dB during the M092 experiment are without basis. (All available documents have stated that the noise levels for the Orbiting Workshop will be well below this value.) Unless more sensitive measurements such as the GSR are monitored, the noise level need not be a vital concern.

As a future experiment, one could subject the test person to a high level of noise (100 dB) before the test and repeat the above experimental protocol. It would be interesting to investigate the increased sensitivity of an individual to random noise preceded by a period of "composed quietness" to determine if his reaction is more or less as compared to this data.

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama, March 31, 1970
931-31-19-00-62

APPENDIX



REHABILITATION CENTER
DEPARTMENT OF AUDIOLOGY
HISTORY FORM

EXAMINER Trobaugh

DATE September 29, 1969

ROUTINE INFORMATION

FULL NAME: A AGE 33 BIRTHDATE: March 6, 1936

ADDRESS: _____ COUNTY: _____

PHONE NUMBER: _____ OCCUPATION NASA

REFERRED BY: _____

CHIEF COMPLAINT: None

PATIENT'S EVALUATION OF HEARING PROBLEM

DATE OF ONSET: _____

UNDER WHAT CIRCUMSTANCES: _____

PROGRESSION OF LOSS: _____

CAUSE OF LOSS: _____

FAMILY HISTORY OF HEARING LOSS: Yes _____ No X

Relationship _____ when (age) _____

Relationship _____ when (age) _____

MEDICAL TREATMENT FOR HEARING LOSS: _____

When _____ by whom _____

Diagnosis _____ treatment _____

MEDICAL HISTORY

GENERAL HEALTH: Very Good

SERIOUS ILLNESS: None

CHILDHOOD DISEASES: mumps, measles, chicken pox, scarlet fever, others

EAR DRAINAGE: None

EAR ACHES: Very Few

HEAD NOISES None TYPE _____ LOCATION _____
MEDICATION TAKEN REGULARLY: _____ YEAR: _____
EXPOSURE TO LOUD SOUNDS: None MASTOIDITIS _____
DIZZINESS: _____ BLACKOUTS: _____
ACCIDENTS OR FALLS WITH LOSS OF CONSCIOUSNESS: _____

PATIENT'S ANALYSIS OF HEARING PROBLEM NOW:

DOES HEARING VARY No OR REMAIN THE SAME _____
IS LOUD SPEECH INTELLIGIBLE _____
IS HEARING BETTER IN QUIET _____ NOISE _____
IS IT DIFFICULT TO LOCALIZE A SOUND _____
SOUNDS MOST EASILY HEARD _____
SOUNDS MOST DIFFICULT TO HEAR _____
GROUPS _____ INDIVIDUALS _____
TELEPHONE _____ RADIO OR TV _____
AT A DISTANCE _____ AT CLOSE RANGE _____

USE OF HEARING AIDS:

PRESENT MODEL _____ SOLD BY WHOM _____ DATE PURCHASED _____
ATTITUDE TOWARD AIDS _____
MODELS PREVIOUSLY WORN _____ HOW LONG _____
EARPIECE: HAS OWN _____ EAR _____

PREVIOUS TRAINING:

SPEECH READING _____ AUDITORY TRAINING _____
SPEECH CORRECTION _____ WHERE AND WHEN OBTAINED _____

ADDITIONAL COMMENTS:

ABILITY TO HEAR DURING INTERVIEW: _____
SPEECH AND LANGUAGE ABILITY: _____
IS LOSS A VOCATIONAL DISABILITY _____

AUDIOLOGICAL ASSESSMENT

RE: A

ADDRESS: Decatur, Alabama

BIRTHDATE: March 6, 1936

DATE OF EVALUATION: September 29, 1969

A was seen at the Rehabilitation Center in Huntsville, Alabama for an audiological assessment September 29, 1969 to rule out any possibility of a hearing loss. A is an employee at MSFC in Huntsville, Alabama and is participating in the audiological research study associated with the Physiological Laboratory at MSFC under the direction of Dr. Robert E. Allen.

A case history was obtained when the subject came to the Center. This provided information concerning noise exposure as well as pertinent medical history. The subject reported no complaints with his hearing. His general health is good, and he has never suffered excessive ear aches or ear drainage. He reported no exposure to loud sounds.

Hearing acuity was assessed utilizing pure tones and speech audiometric techniques with results on the enclosed audiogram. A Beltone Audiometer (Model 15C), calibrated according to 1964 ISO Standards, was used in the study.

The subject was first tested by air conduction commencing with the right ear. The frequencies tested were 1000, 2000, 4000, 8000, 500, 250, and 125 Hz. A descending psychophysical method was used to obtain the thresholds. The subject was found to have hearing within normal limits. Bone conduction thresholds were then assessed by the same procedure; testing frequencies were 1000, 2000, 4000, 500, and 250 Hz. His bone conduction thresholds were also within normal limits.

Speech audiometric techniques were assessed with the same audiometer. Speech reception thresholds were obtained with live voice utilizing spondee words. The subject's speech reception threshold was 6 dB in the right ear and 3 dB in the left ear. Speech sound discrimination was assessed in a like manner with the use of Harvard's phonetically balanced word lists. The subject's discrimination score was 98 percent in the right ear and 96 percent in the left ear.

In summary, the subject's hearing was found to be within normal limits. He is, therefore, considered a good candidate for the audiological experiment to be carried out in conjunction with the Physiological Laboratory at MSFC.

Submitted by:

Roma Leah Trobaugh
Senior Audiologist

REHABILITATION CENTER

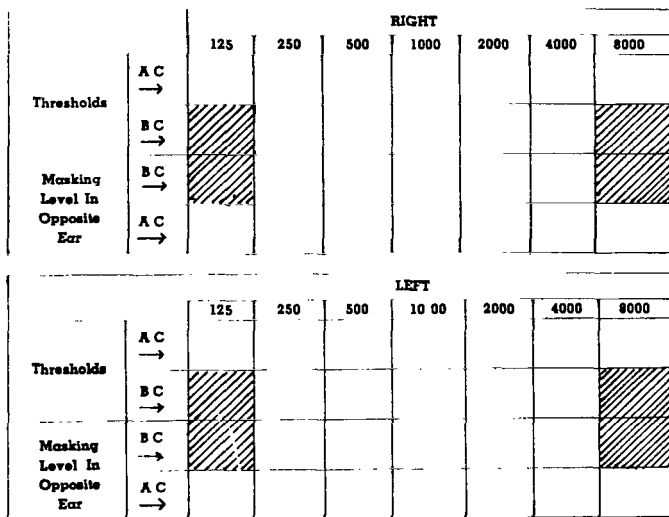
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(AUDIOLOGY)

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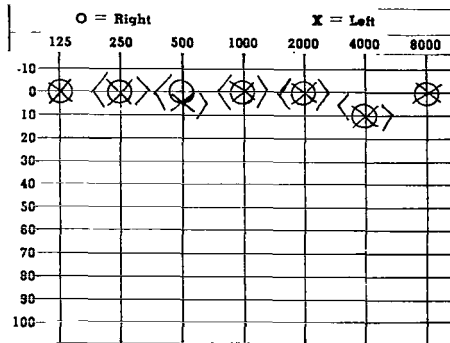
AUDIOLOGICAL EVALUATION

Name	A		Age	33	Sex	M
Address			Telephone			
Patient's Report						
First Noticed Difficulty:			Age:		Years of Loss:	
Cause						
Has Trouble Hearing: <input type="checkbox"/> Individuals <input type="checkbox"/> Groups <input type="checkbox"/> Men <input type="checkbox"/> Women/Children <input type="checkbox"/> Telephone <input type="checkbox"/> Radio/TV <input type="checkbox"/> Bells Hearing: <input type="checkbox"/> Constant <input type="checkbox"/> Varies <input type="checkbox"/> Hearing Today: <input type="checkbox"/> Better <input type="checkbox"/> Same <input type="checkbox"/> Worse <input type="checkbox"/> Cold Today: <input type="checkbox"/> Yes <input type="checkbox"/> No Tinnitus: <input type="checkbox"/> Constant <input type="checkbox"/> Occasional <input type="checkbox"/> None <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Both <input type="checkbox"/> Loud Sounds Annoying: <input type="checkbox"/> Yes <input type="checkbox"/> No Hear Better in: <input type="checkbox"/> Noise <input type="checkbox"/> Quiet <input type="checkbox"/> Better Ear: <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Same						
Date	9-29-69					
Test Number						
Audiologist	Trobaugh					

Hearing For Pure Tones



Audiogram



Pure Tone Summary

Average Loss Within Speech Range			
Ear	AC	AC	BC
	2-Freq.	3-Freq.	3-Freq.
Right		O	O
Left		O	O

REMARKS:

Hearing For Speech

Live Voice		Recorded			
Ear	Speech Reception	Discrimination Score (PB Max.)			
	Threshold (SRT)	PB Score	PB Level		
Right	6 db	98 %	46	db	
Left	3 db	96 %	43	db	
B o t h	Phones	db	%	db	
	Sound Field	db	%	db	

Additional Test Results

Most Comfortable Loudness Level (MCL)	Uncomfortable Loudness Level (UCL)	Dynamic Range

□ OVER

Case histories and audiological assessment reports were compiled on each subject as demonstrated on the previous pages. All subjects reported no complaints with hearing, no exposure to loud sounds, and no medical problems. All had hearing within normal limits. Deviations noted among the subjects were as follows:

		Subjects				
		A	B	C	D	E
Date of Evaluation		9-29-69	9-26-69	9-30-69	9-26-69	9-29-69
Age		33	26	29	32	31
Birthdate		3-6-36	3-10-43	4-11-40	1-4-37	9-24-38
Address		Decatur, Ala.	Huntsville, Ala.	Huntsville, Ala.	Huntsville, Ala.	Madison, Ala.
Earaches		Very Few	None	None	None	None
Speech Reception Threshold	Right Ear	6 dB	6 dB	8 dB	6 dB	6 dB
	Left Ear	3 dB	6 dB	5 dB	5 dB	8 dB
Discrimination Score	Right Ear	98 %	100 %	96 %	96 %	96 %
	Left Ear	96 %	98 %	96 %	96 %	100 %

REHABILITATION CENTER

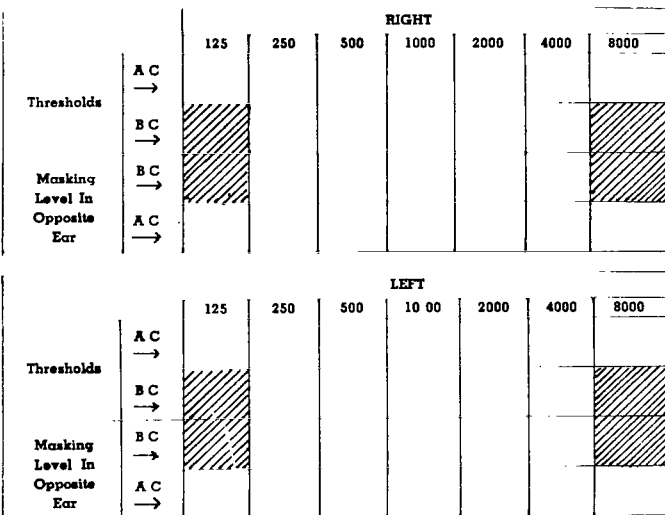
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(AUDIOLOGY)

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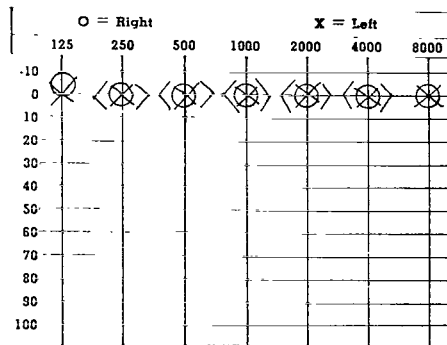
AUDIOLOGICAL EVALUATION

Name B Age 26 Sex M
Address _____ Telephone _____ Date 9-26-69
Patient's Report
First Noticed Difficulty: None Age: _____ Years of Loss: _____
Cause _____ Test Number _____
Audiologist Trobaugh
Has Trouble Hearing: ☐ Individuals ☐ Groups ☐ Men ☐ Women/Children ☐ Telephone ☐ Radio/TV ☐ Bells
Hearing: ☐ Constant ☐ Varies ☐ Hearing Today: ☐ Better ☐ Same ☐ Worse Cold Today: ☐ Yes ☐ No
Tinnitus: ☐ Constant ☐ Occasional ☐ None ☐ Right ☐ Left ☐ Both Loud Sounds Annoying: ☐ Yes ☐ No
Hear Better in: ☐ Noise ☐ Quiet Better Ear: ☐ Right ☐ Left ☐ Same

Hearing For Pure Tones



Audiogram



Pure Tone Summary

Average Loss Within Speech Range

Ear	AC		BC	
	2-Freq.	3-Freq.	2-Freq.	3-Freq.
Right		O		O
Left		O		O

REMARKS:

Hearing For Speech

Live Voice		Recorded			
Ear	Speech Reception Threshold (SRT)	Discrimination Score (PB Max.)		PB Level	
		PB Score	PB Level	PB Score	PB Level
Right	6 db	100 %			db
Left	6 db	98 %			db
Phone	db	%			db
Sound Field	db	%			db

Additional Test Results

Most Comfortable Loudness Level (MCL)	Uncomfortable Loudness Level (UCL)	Dynamic Range

☐ OVER

REHABILITATION CENTER
HEARING DEPARTMENT
(AUDIOLOGY)

316 LONGWOOD DR., S. W.
HUNTSVILLE, ALABAMA 35801

AUDIOLOGICAL EVALUATION

Name C Age 24 Sex M
Address _____ Telephone _____
Date 9-30-69
Test Number _____
Audiologist Trobaugh

Patient's Report
First Noticed Difficulty: _____ Age: _____ Years of Loss: _____
Cause: _____

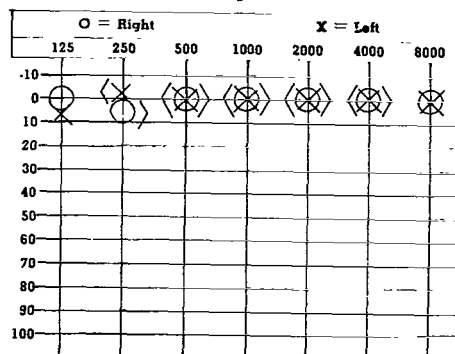
Has Trouble Hearing: ☐ Individuals ☐ Groups ☐ Men ☐ Women/Children ☐ Telephone ☐ Radio/TV ☐ Bells
Hearing: ☐ Constant ☐ Varies ☐ Hearing Today: ☐ Better ☐ Same ☐ Worse Cold Today: ☐ Yes ☐ No
Tinnitus: ☐ Constant ☐ Occasional ☐ None ☐ Right ☐ Left ☐ Both Loud Sounds Annoying: ☐ Yes ☐ No
Hear Better in: ☐ Noise ☐ Quiet Better Ear: ☐ Right ☐ Left ☐ Same

Hearing For Pure Tones

		RIGHT						
		125	250	500	1000	2000	4000	8000
Thresholds	AC →							
	BC →							
Masking Level in Opposite Ear	BC →							
	AC →							

		LEFT						
		125	250	500	1000	2000	4000	8000
Thresholds	AC →							
	BC →							
Masking Level in Opposite Ear	BC →							
	AC →							

Audiogram



Pure Tone Summary

Average Loss Within Speech Range			
Ear	AC	AC	BC
	2-Freq.	3-Freq.	3-Freq.
Right		O	O
Left		O	O

REMARKS:

Hearing For Speech

Live Voice		Recorded			
Ear	Speech Reception Threshold (SRT)	Discrimination Score (PB Max.)			
		PB Score		PB Level	
Right	8 db	96	%	48	db
Left	5 db	96	%	45	db
Both	Phones		%		db
	Sound Field		%		db

Additional Test Results

Most Comfortable Loudness Level (MCL)	Uncomfortable Loudness Level (UCL)	Dynamic Range

☐ OVER

REHABILITATION CENTER

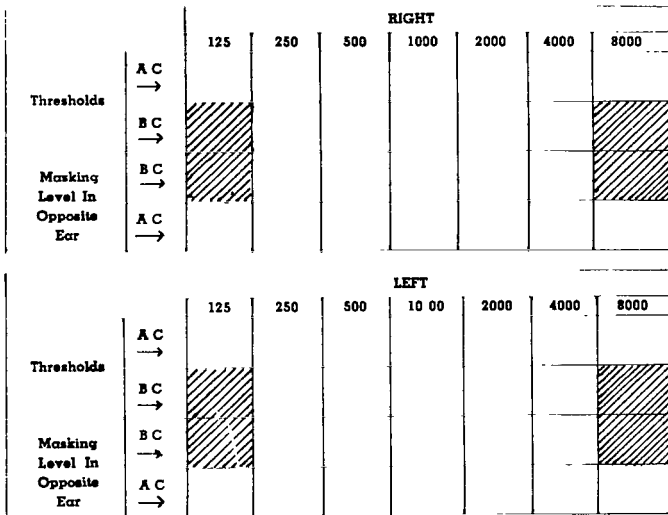
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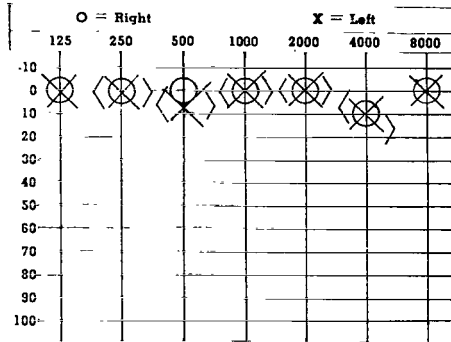
AUDIOLOGICAL EVALUATION

Name	D	Age	32	Sex	M
Address				Telephone	
Patient's Report				Date	9-26-69
First Noticed Difficulty:			Age:	Years of Loss:	Test Number:
Cause			Audiotologist Trobaugh		
Has Trouble Hearing: <input type="checkbox"/> Individuals <input type="checkbox"/> Groups <input type="checkbox"/> Men <input type="checkbox"/> Women/Children <input type="checkbox"/> Telephone <input type="checkbox"/> Radio/TV <input type="checkbox"/> Bells Hearing: <input type="checkbox"/> Constant <input type="checkbox"/> Varies <input type="checkbox"/> Hearing Today: <input type="checkbox"/> Better <input type="checkbox"/> Same <input type="checkbox"/> Worse <input type="checkbox"/> Cold Today: <input type="checkbox"/> Yes <input type="checkbox"/> No Tinnitus: <input type="checkbox"/> Constant <input type="checkbox"/> Occasional <input type="checkbox"/> None <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Both <input type="checkbox"/> Loud Sounds Annoying: <input type="checkbox"/> Yes <input type="checkbox"/> No Hear Better in: <input type="checkbox"/> Noise <input type="checkbox"/> Quiet <input type="checkbox"/> Better Ear: <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Same					

Hearing For Pure Tones



Audiogram



Pure Tone Summary

Ear	Average Loss Within Speech Range		
	AC 2-Freq.	AC 3-Freq.	BC 3-Freq.
Right		O	O
Left		O	O

REMARKS:

Hearing For Speech

Live Voice		Recorded			
Ear	Speech Reception Threshold (SRT)	Discrimination Score (PB Max.)	PB Score		PB Level
Right	6 db	96 %			46 db
Left	5 db	96 %			45 db
Phone	db	%			db
Sound Field	db	%			db

Additional Test Results

Most Comfortable Loudness Level (MCL)	Uncomfortable Loudness Level (UCL)	Dynamic Range

☐ OVER

HEARING DEPARTMENT
(AUDIOLOGY)

REHABILITATION CENTER

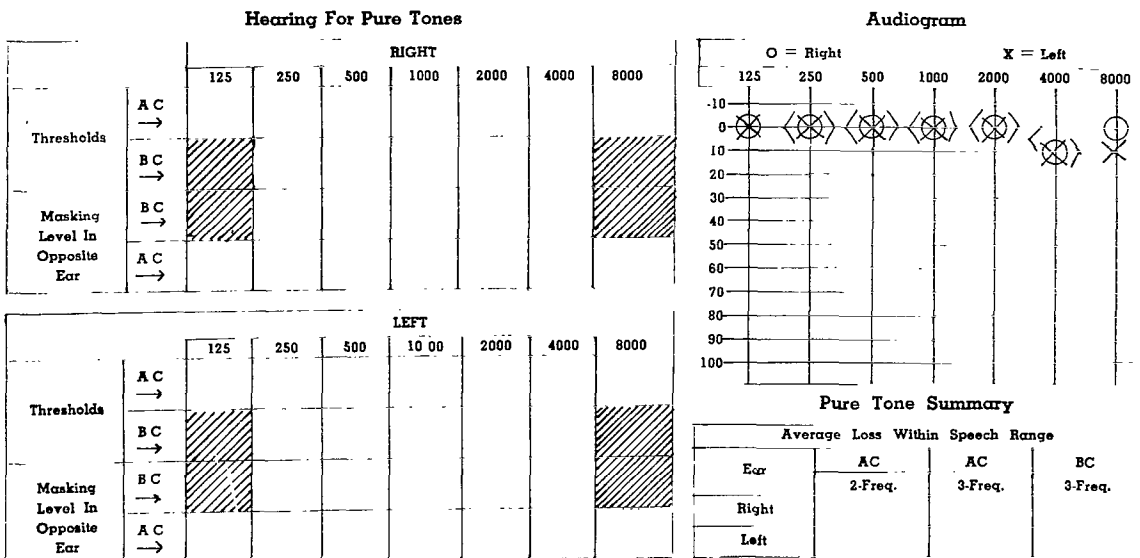
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HUNTSVILLE, ALABAMA 35801

AUDIOLOGICAL EVALUATION

Name E Age 31 Sex
Address Telephone
Date 9-29-69
Test Number
Audiologist Trobaugh

Patient's Report
First Noticed Difficulty: Age: Years of Loss:
Cause

Has Trouble Hearing ☐ Individuals ☐ Groups ☐ Men ☐ Women/Children ☐ Telephone ☐ Radio/TV ☐ Bells
Hearing: ☐ Constant ☐ Varies ☐ Hearing Today: ☐ Better ☐ Same ☐ Worse Cold Today: ☐ Yes ☐ No
Tinnitus: ☐ Constant ☐ Occasional ☐ None ☐ Right ☐ Left ☐ Both Loud Sounds Annoying: ☐ Yes ☐ No
Hear Better in: ☐ Noise ☐ Quiet Better Ear: ☐ Right ☐ Left ☐ Same



REMARKS:

Hearing For Speech

Ear	Speech Reception Threshold (SRT)	Discrimination Score (PB Max.)	
		PB Score	PB Level
Right	6 db	96 %	46 db
Left	8 db	100 %	48 db
Both	Phones		
Sound Field			

Additional Test Results

Most Comfortable Loudness Level (MCL)	Uncomfortable Loudness Level (UCL)	Dynamic Range

☐ OVER

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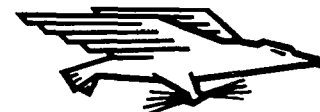
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